

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Metallic cables and other passive components test methods –
Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring
of transfer impedance Z_T and screening attenuation a_S or coupling attenuation
 a_C of connectors and assemblies – Triaxial tube in tube method**

**Méthodes d'essai des câbles métalliques et autres composants passifs –
Partie 4-7: Compatibilité électromagnétique (CEM) – Méthode d'essai pour
mesurer l'impédance de transfert, Z_T , et l'affaiblissement d'écrantage, a_S , ou
l'affaiblissement de couplage, a_C , des connecteurs et des cordons – Méthode
triaxiale en tubes concentriques**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC online collection - oc.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Metallic cables and other passive components test methods –
Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring
of transfer impedance Z_T and screening attenuation a_S or coupling attenuation
 a_C of connectors and assemblies – Triaxial tube in tube method**

**Méthodes d'essai des câbles métalliques et autres composants passifs –
Partie 4-7: Compatibilité électromagnétique (CEM) – Méthode d'essai pour
mesurer l'impédance de transfert, Z_T , et l'affaiblissement d'écrantage, a_S , ou
l'affaiblissement de couplage, a_C , des connecteurs et des cordons – Méthode
triaxiale en tubes concentriques**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.100.10; 33.120.10

ISBN 978-2-8322-9988-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references.....	9
3 Terms and definitions	10
4 Physical background.....	12
5 Principle of the test methods.....	12
5.1 General.....	12
5.2 Transfer impedance	13
5.3 Screening attenuation	13
5.4 Coupling attenuation	14
6 Test procedure	15
6.1 General.....	15
6.2 Tube in tube procedure	15
6.3 Test equipment	16
6.4 Calibration procedure	16
6.5 Connection between extension tube and device under test.....	17
6.6 Dynamic range respectively noise floor.....	17
6.7 Impedance matching	18
6.8 Influence of adapters.....	18
7 Sample preparation	19
7.1 Coaxial connector or device	19
7.2 Balanced or multiconductor device	19
7.3 Cable assembly	21
8 Measurement of transfer impedance	21
8.1 General.....	21
8.2 Principle block diagram of transfer impedance	21
8.3 Measuring procedure – Influence of connecting cables.....	22
8.4 Measuring.....	22
8.5 Evaluation of test results	22
8.6 Test report	23
9 Screening attenuation.....	23
9.1 General.....	23
9.2 Impedance matching	23
9.2.1 General	23
9.2.2 Evaluation of test results with matched conditions.....	24
9.2.3 Measuring with mismatch	25
9.2.4 Evaluation of test results	25
9.3 Test report.....	25
10 Coupling attenuation.....	26
10.1 General.....	26
10.2 Procedure for testing connectors	26
10.3 Procedure for testing cable assemblies.....	27
10.4 Evaluation of test results when using a balun.....	28
10.5 Evaluation of test results when using a multiport VNA	28

10.6 Test report	29
Annex A (normative) Determination of the impedance of the inner circuit	30
Annex B (informative) Example of a self-made impedance matching adapter.....	31
Annex C (informative) Measurements of the screening effectiveness of connectors and cable assemblies	33
C.1 General.....	33
C.2 Physical basics	33
C.2.1 General coupling equation.....	33
C.2.2 Coupling transfer function	35
C.3 Triaxial test set-up	37
C.3.1 General	37
C.3.2 Measurement of cable assemblies	38
C.3.3 Measurement of connectors	39
C.4 Conclusion.....	42
Annex D (informative) Influence of contact resistances	43
Annex E (informative) Direct measurement of screening effectiveness of connectors	45
E.1 Scope	45
E.2 Test set-up.....	45
E.3 Construction details of test set-up.....	46
Annex F (normative) Mixed mode S-parameters	48
F.1 General.....	48
F.2 Definition of mixed mode S-parameters	48
F.3 Reference impedance of a VNA.....	51
Annex G (normative) Accessories for measuring coupling attenuation	52
G.1 TP connecting unit	52
G.2 Termination of the DUT	52
G.3 Test adapter	53
G.3.1 General	53
G.3.2 Direct feeding with coaxial cables.....	53
G.3.3 Balanced feeding cable	54
G.3.4 Movable short circuit.....	54
Annex H (informative) Low frequency screening attenuation	56
Bibliography	57
Figure 1 – Definition of Z_T	10
Figure 2 – Principle of the test set-up to measure transfer impedance and screening or coupling attenuation of connectors with tube in tube	13
Figure 3 – Principle of the test set-up to measure transfer impedance and screening attenuation of a cable assembly	15
Figure 4 – Principle set-up for verification test.....	18
Figure 5 – Preparation of balanced or multiconductor connectors.....	21
Figure 6 – Test set-up (principle) for transfer impedance measurement according to test of IEC 62153-4-3 with load resistor in inner circuit and without damping resistor in outer circuit	22
Figure 7 – Measuring the screening attenuation with tube in tube with impedance matching device.....	24
Figure 8 – Coupling attenuation, principle test set-up with 2-port VNA and balun.....	26

Figure 9 – Coupling attenuation, principle set-up with multiport VNA and TP-connecting unit.....	27
Figure 10 – Coupling attenuation, principle test set-up with multiport VNA and TP-connecting unit for measuring complete cable assemblies	27
Figure 11 – Coupling attenuation, principle test set-up with multiport VNA and TP-connecting unit for measuring halved cable assemblies.....	28
Figure 12 – Typical measurement of a connector of 0,04 m length with 1 m extension tube ..	29
Figure B.1 – Attenuation and return loss of a 50 Ω to 5 Ω impedance matching adapter, log scale.....	31
Figure B.2 – Attenuation and return loss of a 50 Ω to 5 Ω impedance matching adapter, lin scale.....	32
Figure C.1 – Equivalent circuit of coupled transmission lines	34
Figure C.2 – Summing function S	35
Figure C.3 – Calculated coupling transfer function ($l = 1$ m; $\epsilon_{r1} = 2,3$; $\epsilon_{r2} = 1$; $Z_F = 0$).....	36
Figure C.4 – Triaxial set-up for the measurement of the screening attenuation a_S and the transfer impedance Z_T	37
Figure C.5 – Simulation of a cable assembly (logarithmic scale)	39
Figure C.6 – Simulation of a cable assembly (linear scale).....	39
Figure C.7 – Triaxial set-up with extension tube for short cable assemblies.....	40
Figure C.8 – Triaxial set-up with extension tube for connectors.....	40
Figure C.9 – Simulation, logarithmic frequency scale	41
Figure C.10 – Measurement, logarithmic frequency scale.....	41
Figure C.11 – Simulation, linear frequency scale	41
Figure C.12 – Measurement, linear frequency scale.....	41
Figure C.13 – Simulation, logarithmic frequency scale	42
Figure C.14 – simulation, linear frequency scale	42
Figure D.1 – Contact resistances of the test set-up.....	43
Figure D.2 – Equivalent circuit of the test set-up.....	43
Figure E.1 – Principle of the test set-up to measure transfer impedance and screening attenuation of a connector.....	45
Figure E.2 – Principle of the test set-up to measure transfer impedance and screening attenuation of a cable assembly	46
Figure E.3 – Example of sample preparing	46
Figure E.4 – Screening tube with separate nut.....	47
Figure E.5 – Screening fixed with associated nut.....	47
Figure F.1 – Common two-port network	48
Figure F.2 – Common four port network.....	48
Figure F.3 – Physical and logical ports of a VNA	49
Figure F.4 – Nomenclature of mixed mode S-parameters.....	49
Figure F.5 – Measurement configuration, single ended response	50
Figure F.6 – Measurement configuration, differential mode response	51
Figure G.1 – Termination of the device under test, principle.....	53
Figure G.2 – Balunless measurement of coupling attenuation of a balanced connector, direct feeding, principle.....	54
Figure G.3 – Balunless measurement of coupling attenuation of a cable assembly using balanced feeding cable, principle	54

Figure G.4 – Balunless measurement of coupling attenuation of a cable assembly using adapters with implemented short circuit, principle.....	55
Figure H.1 – Example for a screening attenuation test result of a cable assembly with a test length of 2 meters	56
Table 1 – IEC 62153, Metallic communication cable test methods – Test procedures with triaxial test set-up	12
Table G.1 – TP-connecting unit performance characteristics (100 kHz to 2 GHz).....	52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**METALLIC CABLES AND OTHER PASSIVE
COMPONENTS TEST METHODS –****Part 4-7: Electromagnetic compatibility (EMC) –
Test method for measuring of transfer impedance Z_T and screening
attenuation a_S or coupling attenuation a_C of connectors and assemblies –
Triaxial tube in tube method**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62153-4-7 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This third edition cancels and replaces the second edition published in 2015 and its Amendment 1:2018. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

The document is revised and updated. It now includes IEC 62153-4-7:2015/COR1:2016 and IEC 62153-4-7:2015/AMD1:2018. Furthermore, the changes of the revised IEC 62153-4-9:2018 are included.

Measurements of the coupling attenuation can be achieved now by using a mixed mode network analyser (virtual balun). The following new annexes have been added:

- Annex E contains informative information about the direct measurement of screening effectiveness of connectors;
- Annex F gives normative information about mixed mode parameters;
- Annex G contains normative information about accessories for measuring coupling attenuation;
- Annex H discusses the low frequency screening attenuation.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
46/812/FDIS	46/820/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts of the IEC 62153 series, under the general title *Metallic cables and other passive components test methods* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The shielded screening attenuation test set-up according to IEC 62153-4-3 and IEC 62153-4-4 have been extended to take into account the particularities of electrically short elements like connectors and cable assemblies. Due to the concentric outer tube of the triaxial set-up, measurements are independent of irregularities on the circumference and outer electromagnetic fields.

With the use of an additional resonator tube (inner tube respectively tube in tube), a system is created where the screening effectiveness of an electrically short device is measured in realistic and controlled conditions. Also, a lower cut off frequency for the transition between electrically short (transfer impedance Z_T) and electrically long (screening attenuation a_S) can be achieved.

A wide dynamic and frequency range can be applied to test even super screened connectors and assemblies with normal instrumentation from low frequencies up to the limit of defined transversal waves in the outer circuit at approximately 4 GHz.

METALLIC CABLES AND OTHER PASSIVE COMPONENTS TEST METHODS –

Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_S or coupling attenuation a_C of connectors and assemblies – Triaxial tube in tube method

1 Scope

This part of IEC 62153 deals with the triaxial tube in tube method. This triaxial method is suitable to determine the surface transfer impedance and/or screening attenuation and coupling attenuation of mated screened connectors (including the connection between cable and connector) and cable assemblies. This method could also be extended to determine the transfer impedance, coupling or screening attenuation of balanced or multipin connectors and multicore cable assemblies. For the measurement of transfer impedance and screening- or coupling attenuation, only one test set-up is needed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62153-4-1:2014, *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic screening measurements*

IEC 62153-4-3, *Metallic communication cable test methods – Part 4-3: Electromagnetic Compatibility (EMC) – Surface transfer impedance – Triaxial method*

IEC 62153-4-4, *Metallic communication cable test methods – Part 4-4: Electromagnetic compatibility (EMC) – Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial method*

IEC 62153-4-8, *Metallic cables and other passive components – Test methods – Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance*

IEC 62153-4-9:2018, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

IEC 62153-4-10, *Metallic communication cable test methods – Part 4-10: Electromagnetic compatibility (EMC) – Transfer impedance and screening attenuation of feed-throughs and electromagnetic gaskets - Double coaxial test method*

IEC 62153-4-15:2015, *Metallic communication cable test methods – Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell*

IEC 62153-4-16, *Metallic communication cable test methods – Part 4-16: Electromagnetic compatibility (EMC) – Extension of the frequency range to higher frequencies for transfer impedance and to lower frequencies for screening attenuation measurements using the triaxial set-up*

EN 50117-9-2:2019, *Coaxial cables – Part 9-2: Sectional specification for coaxial cables for analogue and digital transmission – Indoor droop cables for systems operating at 5 MHz – 3 000 MHz*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

surface transfer impedance

Z_T

for an electrically short screen, quotient of the longitudinal voltage U_1 induced to the inner circuit by the current I_2 fed into the outer circuit or vice versa

Note 1 to entry: The surface transfer impedance is expressed in ohms.

Note 2 to entry: The value Z_T of an electrically short screen is expressed in ohms [Ω] or decibels in relation to 1 Ω .

Note 3 to entry: See Figure 1.

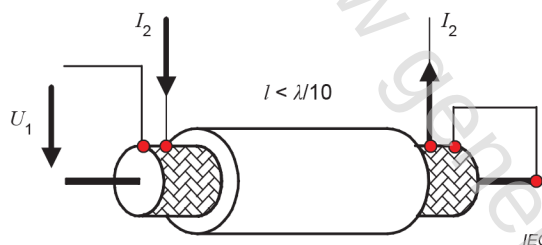


Figure 1 – Definition of Z_T

$$Z_T = \frac{U_1}{I_2} \quad (1)$$

$$Z_T \text{ dB}(\Omega) = +20 \times \log_{10} \left(\frac{|Z_T|}{1 \Omega} \right) \quad (2)$$

3.2

effective transfer impedance

Z_{TE}

maximum absolute value of the sum or difference of the capacitive coupling impedance Z_F and the transfer impedance Z_T at every frequency: